IS THERE UNIFORMITARIAN OR CATASTROPHIC TECTONICS ON VENUS? Donald L. Turcotte, Department of Geological Sciences, Cornell University, Ithaca, NY 14853

The distribution and modification of craters on Venus favors a near global, volcanic resurfacing event about 500 Myrs ago [1,2]. Such an event indicates that the tectonic evolution of Venus has been catastrophic rather than uniformitarian.

The creation of a global, single-plate lithosphere on Venus about 500 Myrs ago can explain a variety of tectonic features on Venus that are not consistent with the thin lithosphere required by a uniformitarian hypothesis. A lithosphere on Venus that has thickened for 500 Myrs has a present thickness of about 300 km whereas steady-state heat loss from Venus requires a mean lithospheric thickness near 40 km. A thick lithosphere on Venus can support the high plateaus (elevations of 3-4 km) and mountain belts (up to 9 km) using the same isostatic compensation concepts applicable to the earth. If a thick lithosphere is thinned by a mantle plume, elevation is caused by thermal isostasy. The elevation due to the thinning of a 300 km thick lithosphere is about 3 km. Thus the domal elevation of Beta Regio [3] can be explained by the same mechanism responsible for the elevation of the Hawaiian Swell. While the broad highland plateaus on Venus may be associated with thermal isostasy, the mountain belts in Ishtar Terra clearly cannot be. The high topography of Freyja Montes is almost certainly associated with underthrusting and the likely compensation mechanism is Airy isostasy associated with a thickened crust [4]. With a density contrast Δ, of 500 kg m^{-3} an elevation of 9 km requires a crustal thickening of about 70 km. With a thick lithosphere there is no difficulty in supporting such a thick crust.

Unlike on earth, gravity anomalies correlate with high topography on Venus. Large positive gravity anomalies are directly associated with Beta Regio and Aphrodite Terra. These features are at least 75% compensated but the associated gravity anomalies are much larger than those found on the earth. For compensated topography, the geoid-topography ratio (GTR) is a measure of the associated gravity anomaly. Smrekar and Phillips [5] have obtained GTRs for elevated regions on Venus. They find that Beta has the highest value with a GTR $= 31\pm2$ m/km. An explanation for the high topography on Venus must also be able to explain the large associated gravity anomalies. Thermal isostasy with a 300 km thick lithosphere gives GTR=20 m/km.

With a stable thickening lithosphere the heat flux to the surface is less than the heat generated within Venus, thus the mean interior temperature will increase. The rate of increase is about 100°K/Gyr. Although such an increase appears to be small, it can have a profound influence on the rates of plume generation and volcanism in a planetary interior.

Another major feature that is unique to Venus are the coronae [6,7]. These are quasi-circular features, 100-2600 km in diameter, with raised interiors and elevated rims, often with annular troughs. McKenzie et al. [8] have argued that the perimeter of several large coronae on Venus, specifically Artemis, Latona, and Eithinoha, resemble terrestrial subduction zones in both platform and topography. Artemis chasma has a radius of curvature similar to that of the South Sandwich subduction zone on the earth. Sandwell and Schubert [9] have shown that the morphology of several coronae are in good agreement with the lithospheric flexure models that have been successful in explaining the sea floor morphology at ocean trenches on this planet. Their fluxural profiles yield elastic lithosphere thicknesses of 37 km for Artemis, 35 km for Latona, 15 km for Eithona, 40 km for Heng-O, and 18 km for Freyja. At depths of 15-35 km the temperatures in a stable, 500 Myr old lithosphere are 840-960°K, these are reasonable values for the base of an elastic lithosphere.

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The propagation of a near circular subduction zone could lead to the destruction of the global lithospheric plate in one relatively short subduction episode. This could lead to a period of global surface volcanism and high heat flow that would cool the interior of Venus. Eventually the lithosphere would stabilize and thicken by conduction. This episode of catastrophic subduction of a thick lithosphere followed by a period of extensive volcanism is consistent with many Magellan observations. Parmentier and Hess [10] have suggested that episodic convection (subduction) is associated with a stable depleted layer on Venus.

Arkani-Hamed and Toksoz [11] suggested that the vigor of mantle convection decayed sufficiently that the lithosphere permanently stabilized 500 Myrs ago. The principal point to be made is that the stabilizing and thickening of a global lithosphere for 500 Myrs can explain the high topographic, the associated gravity anomalies, and the apparent thick elastic lithospheres which cannot be explained by a thin lithosphere.

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